FRD Activities Report
August 2000

Research Programs

NOAA Bronze Medal

Tim Crawford, Jeff French and Jerry Crescenti will receive a NOAA 2000 Bronze Medal Award for their for design and application of a novel airborne instrument system to advance scientific knowledge of air-sea exchange.

Figure 1. Tim Crawford (seated) and Jeff French (standing) prepare the LongEZ for a research flight during the Shoaling Waves Experiment (SHOWEX).

In order to address air-sea coupling, simultaneous atmospheric and oceanic measurements are needed, not just at discrete locations, but over a large range of spatial scales. A low-flying airborne instrument system with innovative *in situ* and remote sensors was developed to acquire the necessary data to better quantify air-sea linkages. The resulting instrument system was successfully deployed in four air-sea interaction experiments and continues to play a key role in investigating the exchange between the atmosphere and ocean. This powerful instrument system incorporates a novel combination of cutting-edge technology which allows the simultaneous high-resolution measurement of atmospheric turbulent fluxes and the physical characteristics of the underlying ocean waves.

The ARL air-sea research team developed an airborne instrument system needed to advance our understanding of air-sea interaction. Direct measurements of the atmosphere and/or the ocean surface are often from stationary(e.g., buoys) or slow moving (e.g., ships) platforms. While much has been learned about how these two fluids are linked to each other with these sort of measurement platforms, a void still existed on how the atmosphere and ocean varied over large spatial scales. Aircraft have begun to fill the void. However, many scientific questions remained unanswered because of limitations or inadequacies of particular aircraft. For starters, many large aircraft can not safely fly at low altitudes near the sea surface. This is essential if one must measure the energy exchange between the atmosphere and ocean. Traditionally, many large research aircraft are aerodynamically “dirty.” That is to say, serious airflow distortions are

created by the propwash from the engines and by the inherent design of the airframe. Thus, turbulence flux measurements are often contaminated with airflow distortions. Finally, larger aircraft must travel at higher speeds to remain airborne. In essence, high airspeeds results in a loss of spatial resolution. That is to say, the aircraft is traveling much too fast to "see" smaller scales of atmospheric and oceanic features which play an important role in the exchange of energy across the air-sea interface.

Figure 2. The LongEZ flying a flux leg near the FRF pier.

Without simultaneous, high-fidelity, near-surface observations of both the atmosphere and the ocean surface, much of the detail of the air-sea coupling is not observable. What is novel about this team effort is their unique solution to this problem by developing an instrument measurement system that allows simultaneous measurement of atmospheric characteristics and ocean wave-state with accuracy never before possible. Three new instrument systems had to be developed and integrated into an airborne observing system.

On the atmospheric side of the problem, a new sensor was required to allow high-fidelity measurements of atmospheric turbulent fluxes. This problem was resolved by the Best Aircraft Turbulence (BAT) probe. The BAT probe (http://www.noaa.inel.gov/frd/Capabilities/Bat/) allows scientists to acquire the three-dimensional wind velocity with accuracies never before achieved. The originality of the BAT probe is that it is a self-contained unit. Numerous commercial approaches exist for retrieving the wind velocity from an aircraft, but all suffer due to the physical separation between the sensors that relate the aircraft's air velocity to its ground velocity. In the BAT probe, all of the measurement sensors are contained within a hemispheric housing. This new design, which adopts modern technology and integrates all of the sensors in one physical location, has allowed important increases in the accuracy of atmospheric turbulence measurements. Further, this technological advance adopted smaller, less expensive solid-state sensors. Lastly, because it is a self-contained unit, the BAT probe has gained international recognition and is rapidly being adopted by other scientists for use on various research aircraft. ARL's scientists have, in essence, developed a highly sophisticated instrument which acts as a "plug-n-play" device to measure winds from any moving platform.

Energy exchange across the air-sea interface is also strongly influenced by long and short ocean waves. Instruments were not readily available for near surface wave observations of these two wave sizes. The team solved the long wave observation problem by designing a laser-array altimeter system. The laser-array measures wave-height and directional-wave spectra for ocean waves greater than 3 m. Through scientific collaborations with NASA scientists and engineers,

the team solved the short wave observation by developing a miniature Ka-band radar. This specially designed radar observes the surface roughness of short waves by measuring the radar backscatter intensity for ocean waves between 1 to 100 cm. For the first time, atmospheric turbulent fluxes could now be directly linked to ocean wave characteristics.

The small aircraft used to deploy these advanced instruments was also a critical part of the solution. The "memory" of air-sea energy exchange fades rapidly with altitude. It was essential that the instrument suite be deployed on a vehicle that could fly at low altitudes and slow flight speeds. While NOAA's Aircraft Operations Center (AOC) maintains an exceptional fleet of aircraft for various research applications, none existed that would permit the collection of atmospheric and oceanic data at low levels with high accuracy. Thus, the ARL air-sea research team employed the use of a small aircraft known as a LongEZ. See http://www.noaa.inel.gov/frd/Capabilities/LongEZ/ for detailed information on the LongEZ. The novel aircraft selected also illustrates the ingenuity of the team. The LongEZ employs an aerodynamically "clean" design which results in very little flow distortion. The large wing area and use of a canard affords exceptional flight stability. As a result, the plane can travel safely at low altitudes and low speeds, an essential requirement needed to understand the exchange of energy between the atmosphere and ocean. The pusher (rear) engine assures that any propwash is to the rear of the aircraft and will not distort any atmospheric measurements. This aircraft is ideally suited for making high-fidelity turbulence measurements with minimal flow distortion.

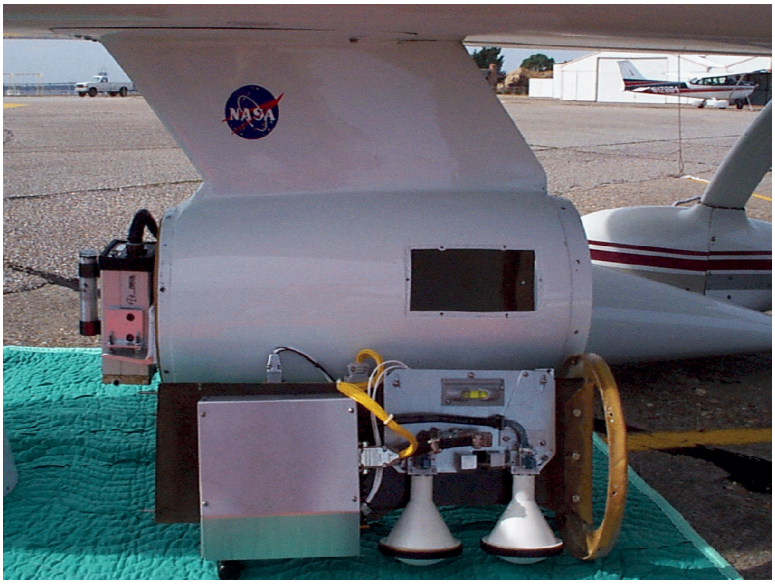

Figure 3. A laser altimeter mounted on the leading edge of the pod with the Ka-band scatterometer removed for display purposes.

From 1997 through 1999, the ARL team deployed their new airborne measurement system in four coastal air-sea research experiments. From these four deployments, an extensive high-quality data base was generated. This data base significantly extends the body of information available on air-sea exchange. These data are being used to develop better parameterizations (i.e., numerical representations) for air-sea exchange coefficients in atmospheric and oceanic forecast models. The team's scientific achievements are best illustrated by more than twenty research publications. The team's findings have also been shared with the scientific community through presentations at various scientific meetings.

These data are already beginning to have an impact within the scientific community. For example, satellite altimeter data are used to precisely measure sea surface height. However, because of the asymmetric shape of waves, radar signals transmitted from these satellites are biased towards

lower values (i.e., lower sea level elevation). The simultaneous atmospheric and oceanic data are being used to understand how the shape of sea surface waves leads to this bias. Through careful analysis, corrections are being developed and applied to these satellite data. As a result, these satellite data of sea level height are more accurate. This is critically important in assessing changes in sea level which can be attributed to global warming. (Tim.Crawford@noaa.gov, Jerry Crescenti and Jeff French)

VTMX-CBNP 2000

The field deployment phase of VTMX-CBNP will occur in only one month. The retrofitting of all whole-air samplers into new sampler boxes has been completed. The re-design and modifications to the mobile SF_6 analyzers are nearly complete (see below). Nearly all SF_6 sampling cartridges have been cleaned and analyzed for contamination, and have received a clean bill of health. In summary, the preparation phase continues on schedule. (Kirk Clawson@noaa.gov and staff)

A new TGA-4000 SF_6 continuous analyzer system was used for background checks in Salt Lake City, Utah in preparation for the VTMX study. A couple of sources were identified but should not present a big problem for the study. The new TGA system performed very well. The operator had only a couple of minor suggestions and no major problems were identified. The new system allows the TGA to be installed in an automobile seat using a standard seat belt to fasten it. This will allow it to be installed a number of different vehicles. It also offers easier operation and computer controlled calibrations.

A series of high concentration tests on the TGA-4000 were conducted in an effort to determine the maximum concentration they were capable of detecting. The results indicate that the detectors become saturated at about 10000 pptv SF_6. By using a factor of 2 dilution system on the incoming sample, the TGA-4000 should be usable up to about 20000 pptv SF_6. Above these concentrations, measurements will not be reliable. (Roger.Carter@noaa.gov)

Some assistance was provided to ATDD in August as part of their logistics and science planning for the VTMX experiment in Salt Lake City. They intend to install a 30 m tower somewhere in the valley and operate the Long-EZ aircraft from the Salt Lake City 2 (location identifier U42) airport. It has proven difficult to find a suitable location for the tower, partly because of the urban sprawl and partly because of FCC regulations related to interference with broadcasting stations. FRD has provided assistance in finding possible locations for the tower and in developing flight plans for the Long-EZ. (Richard.Eckman@noaa.gov, Kirk Clawson, Shane Beard)

Refractive Turbulence Study 2000

Initial field work for RTS00 was completed during a 3 week period from 31 July to 18 August. Nearly 19 hours of data were collected in 9 flights using the LongEZ based out of Idaho Falls airport. The principal objective for this first of two deployments scheduled for 2000 is to determine characteristics of three different airborne temperature probes: the BAT probe (thermistor), the Ultra-Fast Temperature (UFT) probe (fine wire in free-stream), and the Fast, Ultra-Sensitive Temperature (FUST) probe (thermocouple in reduced-flow chamber). Work

continues on data analysis. Currently this focuses on determining recovery factors, resolution, and response for each device. This information is critical to assess how best to obtain the necessary measurements for phase 2 of RTS00, scheduled for late October/early November of this year. (Jeff.French@noaa.gov, Tim Crawford, Ron Dobosy)

Coupled Boundary Layer / Air-Sea Transfer (CBLAST-Low) Initiative

The proposal entitled *Determination of the Spatial Variation of the Atmosphere and Ocean Wave Fields in Extremely Light Wind Regimes* to the Office of Naval Research's (ONR) Coupled Boundary Layers/Air-Sea Transfer (CBLAST) research initiative has been formally approved for funding. This four-year project will start in FY-2001 and will include two deployments of the LongEZ (Summer 2001 and 2002) to Martha's Vineyard. The LongEZ will be an extremely powerful tool for characterizing the spatial variability of the marine atmospheric boundary layer. (Jerry.Crescenti@noaa.gov, Tim Crawford, and Jeff French)

Central California Ozone Study (CCOS)

Data acquisition continues by the nine towers deployed for the Central California Ozone Study (CCOS). Quality control screening efforts have shown that these tower systems are working exceptionally well. However, a few minor problems continue to plague the project. On a recent trip to service several of the towers, the RASS option was turned off by Tom Strong after it was decided that temperature profile data were not being reliably acquired. (Jerry.Crescenti@noaa.gov, Randy Johnson, Neil Hukari, Shane Beard, and Tom Strong)

Cooperative Research with INEEL

INEEL Emergency Operations Center (EOC) Support

Yet another range fire burned 5000 acres on the INEEL from August 5 to 6. An isolated shower produced a single bolt of lightning which ignited the fire during the late afternoon on August 5. The EOC was activated soon after the fire was discovered several miles west of the Environmental Breeder Reactor 2 (EBR-2) facility. Jeff French started the first shift on Saturday evening. He was then relieved by Kirk Clawson at midnight, who was then relieved by Jerry Crescenti at 8 a.m. Sunday morning. Jeff French returned to the EOC on Sunday afternoon at 4 p.m. for several more hours until the fire was brought under control. All three meteorologists provided timely short-range weather forecasts to EOC personnel. (Jerry.Crescenti@noaa.gov, Jeff French, Kirk Clawson)

At the request of the INEEL emergency planning group, FRD generated five sets of "fake weather" for use in emergency response drills and exercises. These are special data sets created to force the meteorological conditions to match the drill scenario. The data are displayed on the INEELViz workstations of the drill participants, allowing them to react as they would in a real emergency situation. (Roger.Carter@noaa.gov)

Jerry Crescenti and Brad Reese (the "A-Team") provided meteorological observations and

modeling support in a scheduled EOC drill on August 23. On the following week, Kirk Clawson and Debbie Lacroix (the "B-Team") provided the same support in an EOC drill. The scenario included a terrorist bombing of a truck with hazardous waste material outside the RWMC facility with another unexploded bomb located at an electric substation. Both teams were integral participants to the success of these drills (Jerry.Crescenti@noaa.gov, Brad Reese, Kirk Clawson, and Debbie Lacroix).

INEEL Wildfire Modeling

A simple wildfire model has been developed for use in the INEEL Emergency Operations Center (EOC). It requires as input the wind speed, wind direction, and fuel moisture content. From these inputs, the model estimates the maximum spread rate and flame length for both grass and sagebrush fuel models. The model code is based on the fireLib function library, developed with support from the U.S. Forest Service. Initially, there were plans to develop a more sophisticated model based on high-resolution vegetation and terrain maps. However, experiences from this summer's wildfires made it clear that detailed real-time information on the fire's location and spatial distribution are difficult to obtain and are subject to frequent revisions. Also, the rapid evolution of the fires means that the information is often out-of-date by the time it reaches the FRD desk in the EOC. The simple model that has been developed is more in-line with the information typically available within the EOC. (Richard.Eckman@noaa.gov)

INEEL Mesoscale Modeling

The length of the daily MM5 forecasts being run at FRD has been increased to 15 hours to better cover the period of maximum afternoon winds. The model is now being initialized at 0900 UTC (0300 MDT), and the forecast is run out to 0000 UTC (1800 MDT). The run usually takes about 3.5 hours to complete on the DEC Alpha workstation. Another enhancement that was completed in August was to write some code that allows MM5 to use data from the FRD Mesonet in its initialization. This code is currently using only the near-surface tower observations, although it may be altered to include the higher altitude data from the radar profiler. The main problem with using the profiler data is the greater risk of introducing spurious values (i.e., noise) into the initialization. The tests performed so far indicate that using the Mesonet observations in the initialization mainly affects the first few hours of the simulation. Beyond that, the simulations with and without the Mesonet data are usually quite similar. (Richard.Eckman@noaa.gov)

Other Activities

AMS Short Course Agenda Finalized

In response to the lack of an instrumentation curriculum at most universities with meteorology programs, the AMS Measurements Committee is organizing a one-day short course on meteorological instrumentation and observation techniques. The focus of the course is on the basics of *in situ* monitoring and will be oriented towards undergraduate and graduate students. This course will be offered on Sunday, January 14, 2001 in conjunction with the 81st Annual Meeting of the American Meteorological Society in Albuquerque, New Mexico. To learn more about short course or the activities of the AMS Committee on Measurements, go to its web site at http://measure.noaa.inel.gov. (Jerry.Crescenti@noaa.gov)

ARL Booth at AMS Annual Meeting

Planning for the ARL Booth as part of the exhibit hall for next year's 81st Annual Meeting of the American Meteorological Society in Albuquerque, New Mexico to be held January 14-19, 2001 is ongoing. The booth is an excellent opportunity to "show off" to the rest of the meteorological community the great research ARL does. One volunteer from each ARL division as well as ARL Headquarters is being asked to help in the development of this booth. Next year's Annual Meeting will represent a significant departure from previous annual meetings. The conference and symposium structure has been modified to create a scientific meeting that better serves the broad spectrum of attendees, with fewer conflicts and with opportunities for presentations that cover much of the breadth of the atmospheric and related oceanic and hydrologic sciences. A major emphasis will be placed on societal impacts. An ARL presence would at least keep some focus on air quality and climate issues.

Barbara Shifflett (ATDD) has agreed to take the lead coordinating the contributions from the various ARL divisions. The ARL staff involved so far include Bruce Hicks (HQ), Barbara Shifflett and Kimberly Hill (ATDD), Evelyn Poole-Kober and Dennis Atkinson (ASMD), and Jerry Crescenti and Tim Crawford (FRD). (Jerry.Crescenti@noaa.gov, Tim Crawford)

Outreach - High School Science Action Team

A Science Action Team (SAT) consisting of high school students from the Upper Snake River Plain area has completed their summer research project. The SAT, sponsored by the INEEL, was lead by Mark Gabrylczyk, a teacher from Idaho Falls High School. The team was comprised of high school students: Stephanie Crapo (Skyline High School), Keith Mecham (Snake River High School), Stacey Peterson (Blackfoot High School), and Lisa Podany (Idaho Falls High School). Their task was to propose solutions for a unique problem facing the food processing plant operated by the Nonpareil Potato Corporation in Blackfoot which produces dehydrated potatoes. The moisture which is extracted from the potatoes in the dehydration processes is released into the atmosphere via smoke stacks which are only about 12 m in height. In the winter during humid inversion conditions, the moisture in the plume quickly saturates and stagnates in the vicinity of the plant. Just downwind of the stacks is U. S. Highway 26. In many instances during these

conditions, visibility along this stretch of road is reduced to near zero. This, of course, has contributed to a number of automobile accidents. Meteorologist Jerry Crescenti was able to provide meteorological guidance to these students and the unique problem they were tasked with. The SAT recently presented their findings and recommendations to the INEEL and Nonpareil Potato Corporation. (Jerry.Crescenti@noaa.gov)

Outreach - Boy Scouts

Jerry Crescenti gave a short presentation about meteorological instruments and observations to Boy Scout Troop 268 from Jackson, Wyoming on August 10. The scouts were on a field trip to learn more about the Idaho National Engineering and Environmental Laboratory (INEEL). The presentation was conducted at the Idaho Environmental Monitoring Program (IEMP) station located on the greenbelt in Idaho Falls. The scouts were able to fill in observation worksheets to learn more about various atmospheric processes. (Jerry.Crescenti@noaa.gov)

Papers

French, J. R., G. H. Crescenti, T. L. Crawford and E. J. Dumas. 2000. LongEZ (N3R) Participation in the 1999 Shoaling Waves Experiment, NOAA Data Report OAR ARL-20, 51 pp.

Vandemark, D., P. D. Mourad, T. L. Crawford, C. A. Vogel, J. Sun, S. A. Bailey and B. Chapron. Measured changes in ocean surface roughness due to atmospheric boundary layer rolls. Final revision submitted for publication in the Journal of Geophysical Research - Ocean.

Watson, Thomas B., Randy Johnson, Marc L. Pitchford, Mark Green, Hampdem Kuhns, and Vicken Etyemezian. In Press.. Perfluorocarbon Tracer Releases During the Big Ben Regional Aerosol and Visibility Observational (BRAVO) Study. Final Revision approved for publication as a NOAA Technical Memorandum.

Travel

Tom Strong to California for the Central California Ozone Study (CCOS) to service tower instrumentation.

August 14-16 Kirk Clawson to Salt Lake City, UT for logistics preparation for the VTMX project in October 2000.

Visitors

Dr. Krzysztof E. Haman, Professor Institute of Geophysics, University of Warsaw

Dr. Owen R. Coté, Air Force Research Laboratory, Hanscom AFB, MA

Ron Dobosy, ATDD